

# The Force Law Design of Artificial Physics Optimization for Starting Population Selection for GSAT

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## **Abstract**

GSAT is a well-known satisfiability search algorithm which uses some random functions. In this paper, we consider an artificial physics optimization for computing a function of starting population.

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Investigation of efficient satisfiability algorithms and encoding different hard problems as instances of SAT has caused considerable interest (see e.g. [1] – [16]). GSAT is a well-known satisfiability algorithm [17]. The GSAT algorithm is a search method for finding a truth assignment for the variables of CNF. GSAT uses some random functions. One of such functions is a function of starting population of truth assignments. In this paper, we consider an intelligent algorithm for computing a function of starting population of truth assignments. This algorithm is based on artificial physics optimization.

Note that artificial physics optimization algorithm (see [18]) consists of three procedures:

- initialization;
- calculation force;
- motion.

A swarm of individuals are sampled randomly from a problem space in the initialization. Masses of individuals should be calculated in the procedure of calculation force. The procedure motion uses the total force to calculate individual velocity. Since a felicitous design of force law can drive individuals search problem space intelligently and efficiently, the main advantage of the artificial physics optimization consists in the proper design of force law.

We consider force law in the general polynomial form

$$F(x[1], \dots, x[n], m[1], \dots, m[n]) = \sum_{i=1}^s \alpha[a[i, 1, 1], \dots, a[i, n, n], b[i, 1], \dots, b[i, n]] \prod_{1 \leq j \leq n, 1 \leq k \leq n, j \neq k} (|x[j] - x[k]|)^{a[i, j, k]} \prod_{p=1}^n m[p]^{b[i, p]}$$

where  $x[i]$  is defined as the position of individual  $i$ ,  $m[i]$  is defined as the mass of individual  $i$ , and  $\alpha$ ,  $a$ ,  $b$  are constants.

Let

$$f(z[1], \dots, z[t])$$

be a CNF. We assume that  $n > t$ , for any possible value of  $t$ . Let  $\#occ^+(f, z[i])$  be the number of positive occurrences of  $z[i]$  in  $f$ ,  $\#occ^-(f, z[i])$  be the number of occurrences of  $\neg z[i]$  in  $f$ . For any  $f$ , we assume that

$$m[i] = \begin{cases} \sum_{j=1}^t \beta[j] (\#occ^+(f, z[i]), \#occ^-(f, z[i])) t^j, & 1 \leq i \leq t, \\ 0, & i > t. \end{cases}$$

We use genetic algorithms to determine the values of the parameters  $\alpha$ ,  $\beta$ ,  $a$ ,  $b$ . In particular, we use the following algorithms for design of force law.

1. A genetic algorithm (GA[1]) to determine the values of

$$\beta[1], \dots, \beta[t].$$

2. A genetic algorithm (GA[2]) to determine the values of

$$[a[i, 1, 1], \dots, a[i, n, n], b[i, 1], \dots, b[i, n]].$$

3. A genetic algorithm (GA[3]) to determine the values of

$$\alpha[a[i, 1, 1], \dots, a[i, n, n], b[i, 1], \dots, b[i, n]].$$

As values of

$$z[1], z[2], \dots, z[t],$$

we consider  $\{0, 1\}$ -discretized values of

$$x[1], x[2], \dots, x[t].$$

In our experiments, we consider standard GSAT and GSAT with the artificial physics optimization for starting population of truth assignments (GSAT-APO). For GSAT and GSAT-APO we consider the same number of truth assignments and the same set of CNF. Also, we use the same number of inversions. Selected experimental results are given in Table 1.

	GSAT	$G[1] = 10^4$	$G[1] = 10^5$	$G[1] = 10^5$	$G[1] = 10^6$	$G[1] = 10^6$
		$G[2] = 10^4$	$G[1] = 10^5$	$G[1] = 10^6$	$G[1] = 10^5$	$G[1] = 10^6$
		$G[3] = 10^4$	$G[1] = 10^5$	$G[1] = 10^6$	$G[1] = 10^5$	$G[1] = 10^6$
$N$	76 %	77 %	84 %	85 %	94 %	95 %

Table 1: Experimental results for GSAT and GSAT-APO with different numbers of generations of genetic algorithms, where  $N$  is a number of solved CNFs,  $G[i]$  is a number of generations of genetic algorithm GA[ $i$ ].

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